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Multidisciplinary Application of
LANDSAT-2 Data to Marine Environment
in Central Japan

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Abstract

Remote sensed data obtained by LANDSAT-2 is very useful for the monitoring the marine environment through the year. In this quarterly progress report, the author described the multidisciplinary application of multi spectral scanner data acquired over central Japan revealed several coastal features including pollution, river effluent, coastal process and etc. with the supporting data obtained by air-born remote sensing.

1 Introduction

The objective of this LANDSAT-2 study is to analyze the marine environment in central Japan and continue the monitoring of it. So, the author set up the test sites in Ise Bay, The Sea of Kumano and Lake Suwa where several coastal features were experienced recently. In this report, the author pointed out the two main topics depend on the special observations with aircraft and vessels. One of the two main topics is the detection of the most effective wavelength for monitoring of red tide and another one topic is the estimation of water exchange between Ise Bay and The Sea of Kumano:Pacific Ocean.

2 Techniques

2-1 Aircraft and Instrument

Before the launching of LANDSAT-2 the author started the pre observation for the purpose of collecting the fundamental data around Ise Bay showed in Figure 1 and Figure 2 by the technique of air-born remote sensing using two types of aircraft.

One is a Cessna-402 showed in Figure 3 and another one is YS-11 turbo jet plane which were equiped with multi spectral scanner. Used multi spectral scanner were two types; Daedalus 1250 eleven channels multi spectral scanner and JSCAN-AT-12M showed in Figure 4 which have twelve wavelength from UV channel to thermal channel. JSCAN-AT-12M multi spectral scanner is developed in the author's study group.

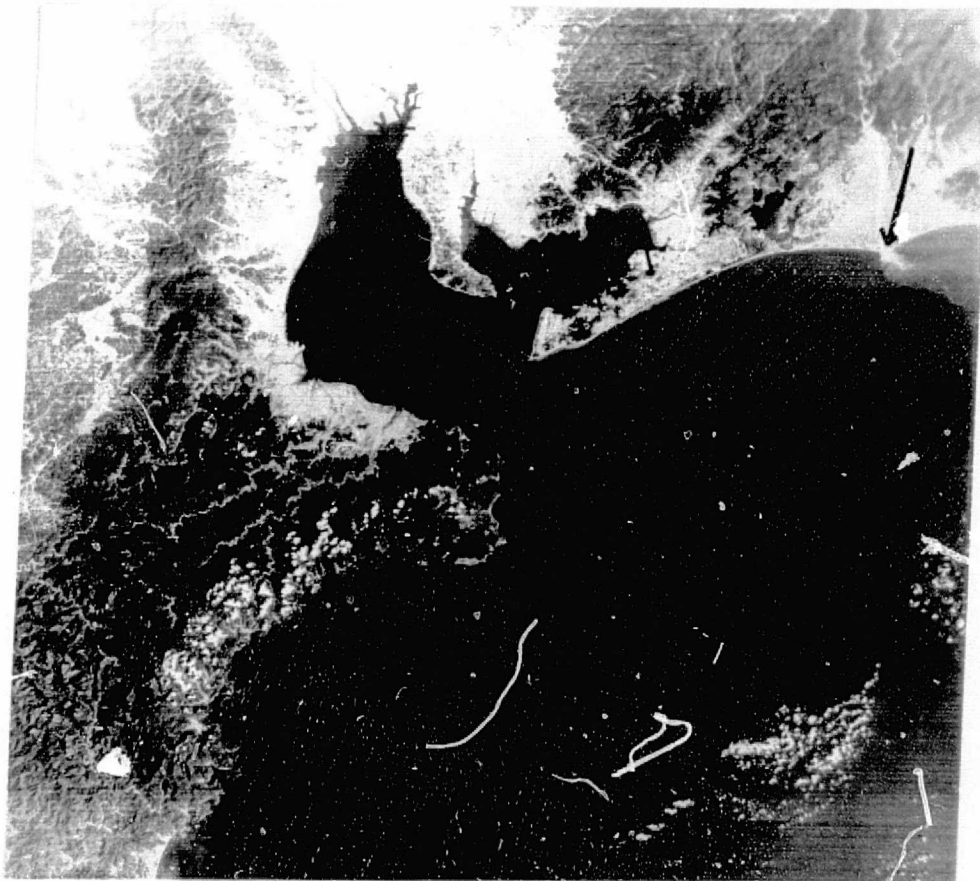


Figure 1 MSS-4 imagery of LANDSAT-2 around Ise Bay.
Sep. 11, 1975

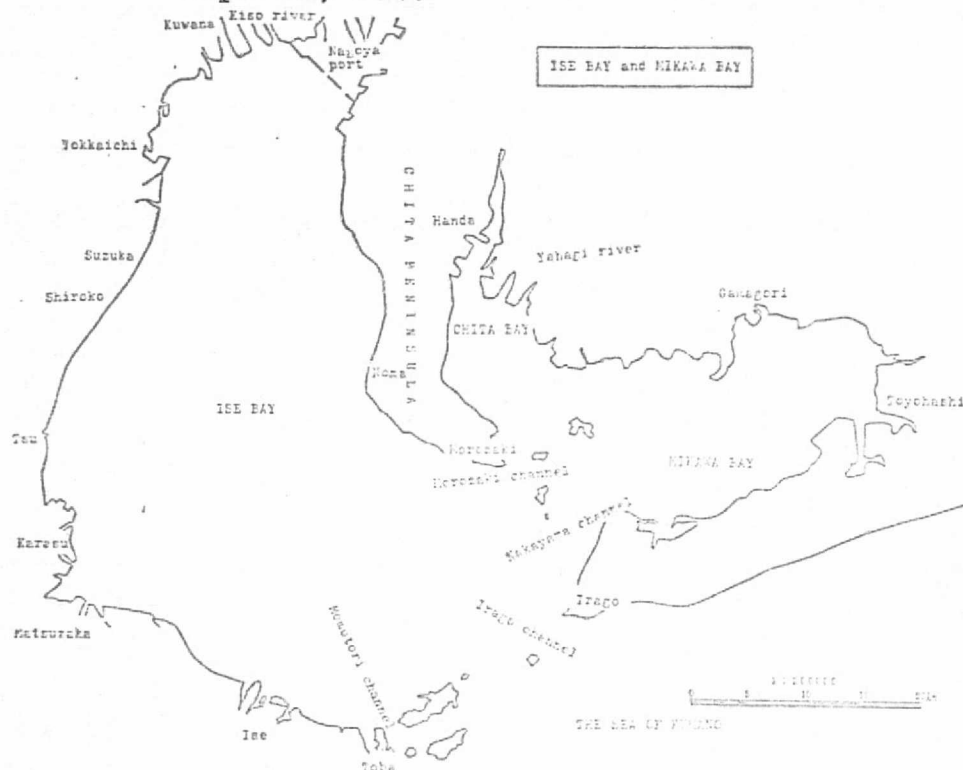


Figure 2 Locations of test site.



Figure 3 Observation aircraft Cessna-402.

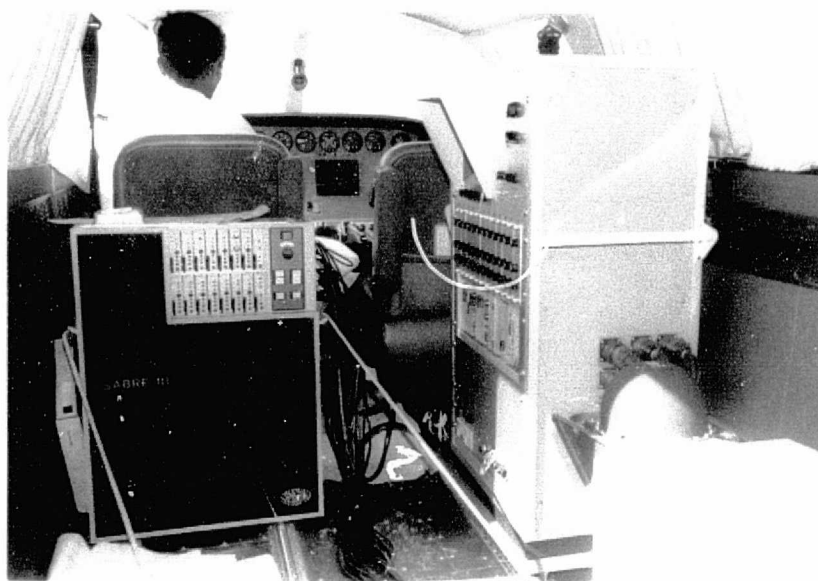


Figure 4 Multi Spectral Scanner JSCAN-At-12M.

After the successful launching of LANDSAT-2, the author tried special observations synchronized with the LANDSAT-2 passing over the test site three times.

2-2 Sea truth data collection

Sea truth data were collected with observation vessels in two types. One hydroboat equipped with a thermometer and a salinometer was used for the daily observation. This hydroboat is engaging daily service for passenger between Toba and Gamagori and she across the Ise Bay four times for a day, so, we could obtaine temperature profile and salinity profile recorded on the paper. In Ise Bay and Mikawa Bay several observation vessels belong to the fisheries experiments are collecting the marine environmental data as routine works and obtained data would be send to the author immediately.

3 Accomplishment

3-1 Red tide monitoring

Ise Bay which is surrounded by Aichi and Mie Prefecture is connected with The Sea of Kumano:Pacific Ocean through the narrow water ways Irigo and Momotori Channel and it has the total amount of water dimension $2.06 \times 10^6 \text{ km}^2$. As shown in Figure 2, Ise Bay is divided in two parts by Chita Peninsula and western half of it is called Ise Bay and easter half is called Mikawa Bay.

Mikawa Bay is again divided in two parts by islands which are located between Morozaki and Yakayama Channel and small western half is named as Chita Bay and large eastern half is named as Mikawa Bay.

Recently, almost Ise Bay including small bays is rapidly polluted by industrial effluent and social discharge from surrounded area. So, we have experienced so many red tide through the year. The total record of red tide appearance was more than one hundred case in 1975 around Ise Bay.

On January 29, we experienced a severe red tide around the mouth of Kiso River in spite of cold season once we have never experienced anywhere in winter. As shown in Table 1, more than fourty five cases of notable red tide were reported last year and some of them were not only very severe, the scale also reportable.

Table 1 Report of red tide sighted in
Ise and Mikawa Bay(only notable case)

Date	Area	Color	Date	Area	Color
1975					
Jan. 29	Mouth of Kiso River	Brown	June 16	Western coast of central Ise Bay	Brown
30					
March 26	Southwest part of Ise Bay	Yellow	June 19	Gamagori Port	Brown
April 7	Along the western coast of central Ise Bay	Light brown	20	Eastern part of Mikawa Bay	Light brown
April 9	Eastern part of Mikawa Bay	Brown	June 25	Almost area of Mikawa Bay	Brown
11			30	Toyohashi Port	Brown
April 16	Northwest part of Ise Bay	Yellow	July 6	Mouth of Toyo River	Green
17			July 9	Western coast of central Ise Bay	Brown
May 1	Eastern part of Mikawa Bay	Pink	11		
May 7	Eastern part of Mikawa Bay	Light brown	July 15	Eastern part of Mikawa Bay	Pink
8	Kinuura Port		16	Along the western coast of Chita Peninsula	Brown
May 21	Kinuura Port	Light brown	17		
May 23	Western coast of central Ise Bay	Pink	Aug. 11	Yokkaichi Port	Brown
May 26	Western coast of northern Ise Bay	Brown	Aug. 20	Central part of Ise Bay	Pink
	Nagoya Port	Brown	Aug. 26	Southwest part of Ise Bay	Light brown
	Northern part of Ise Bay	Brown	Aug. 27	Yokkaichi Port	Dark green
May 26	Eastern part of Mikawa Bay	Brown		Gamagori Port	Black
May 27			Aug. 28	Matsuzaka Port	Brown
May 28	Northern coast of eastern Mikawa Bay	Brown	30		
June 3			Sept. 1	Southwest coast of Ise Bay	Light brown
June 3	Western coast of central Ise Bay	Pink	Sept. 2	Kinuura Port	
4	Eastern coast of Ise Bay	Pink	Sept. 2	Southwest coast of Ise Bay	Light brown
	Kinuura Port	Brown	4		
June 6	Western coast of Ise Bay	Brown	Sept. 8	Northern part of Ise Bay	Light brown
June 10	Eastern part of Mikawa Bay	Brown		Eastern part of Mikawa Bay	Green
14			10	Almost area of Mikawa Bay	Brown
			Oct. 1	Almost area of Mikawa Bay	Brown
			3	Kinuura Port	
			Oct. 8	Eastern part of Mikawa Bay	Brown
			10		

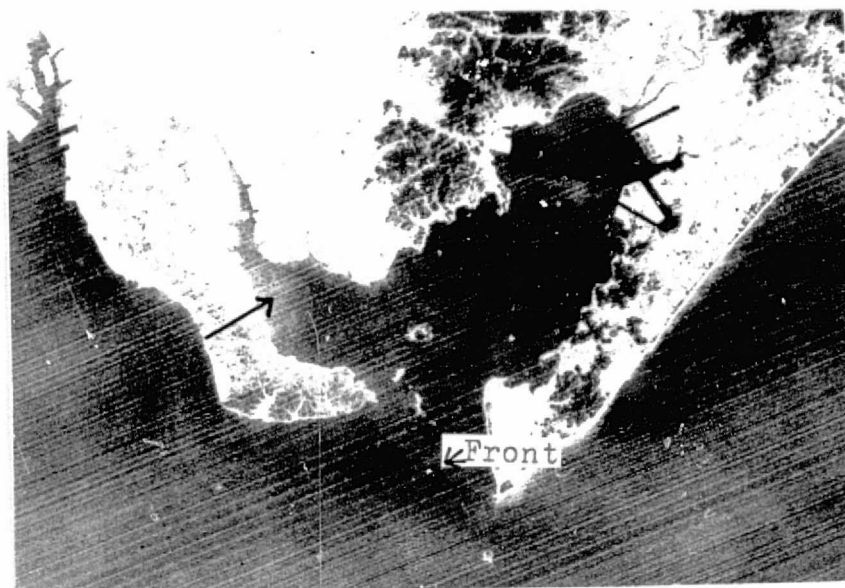


Figure 5 Enlarged MSS-4 imagery showed in Figure 1. Black arrows means the areas of red tide occurred.



Figure 6 Aerial photographs detected red tide in Mikawa Bay near Toyohashi Port. Sept. 11, 1975(10-00JST)

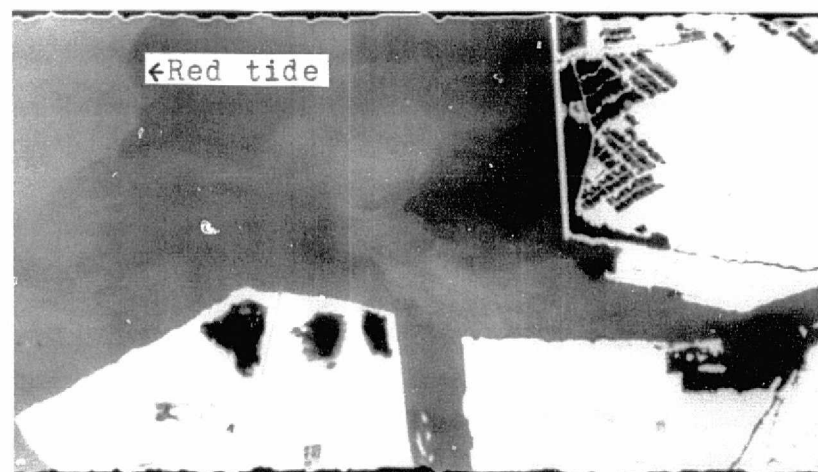


Figure 7 Thermal imageries obtained by aircraft around Mikawa Bay where red tide were occurred. Sept. 11, 1975(10-10JST)

Especially, red tide sighted on May 7—8 in Mikawa Bay, May 26—27 in Ise Bay and Mikawa Bay, June 10—14 and June 25—30 in Mikawa Bay, August 26—September 4 in Ise Bay and September 8—10 were very notable. Because, on these days, a large amount of fish and shell were diseased in the area where red tide were spreaded. Between early April to late December LANDSAT-2 passed over Ise Bay sixteen times. So, if the remote sensed data were collected and reproduced on all times, we could found out a lot of red tide patterns in imagery. But now, the author received only one scene detected on September 11, 1975 when the special experiment by author was tried around Mikawa Bay.

As shown in Figure 1 and Figure 5, several patterns estimated as red tide were detected in MSS-4 imageries in northern part of Ise Bay, Chita Bay and eastern Mikawa Bay. In these area the severe red tide were continued about ten days till September 10. So, the detected patterns were estimated as red tide pattern.

By the remote sensed data obtained by aircraft around the eastern Mikawa Bay, these patterns were recognized as red tide. In Figure 6 aerial color photograph near Toyohashi Port, we could point out the red tide pattern in brown color just the same color reported on September 10, the day before in this area.

In thermal imageries showed in Figure 7, red tide patterns were detected distinctly in the area pointed out in Figure 5 and Figure 6. Depend on the author's experience, the most effective wavelength for the monitoring of red tide consisted by Noctiluca is remarked as thermal channel of air-born multi spectral scanner and it was already reported to NASA₍₁₎. For the red tide consisted by Prorocentrum the most effective wavelength is considered as thermal channel on this experiment. So the author expects the successful launching of LANDSAT-C. Under the present condition of LANDSAT-2, the most effective wavelength for all kind of red tide were estimated as MSS-4 channel.

3-2 Water exchange

For the purpose of monitoring of marine environment in Ise Bay, it is very important task to inquire the water exchange around the mouth of bay. As result of vessel's survey, the water from Pacific Ocean is not so invade into Ise Bay beyond 20 km from the mouth of the bay.

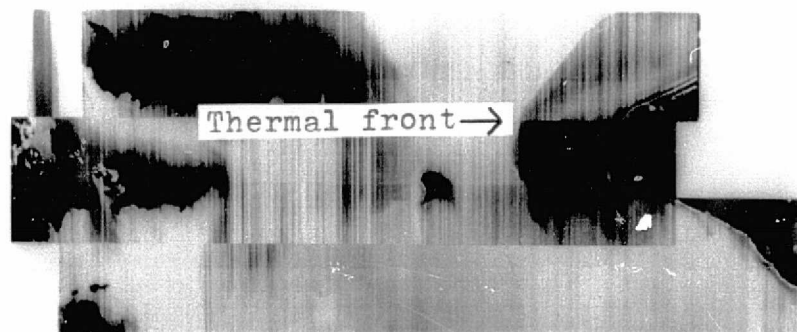


Figure 8 Mosaic of thermal imageries obtained
by aircraft around the entrance of
Ise Bay.
Oct. 24, 1974(15-12~15-36JST) Alt. 2900m

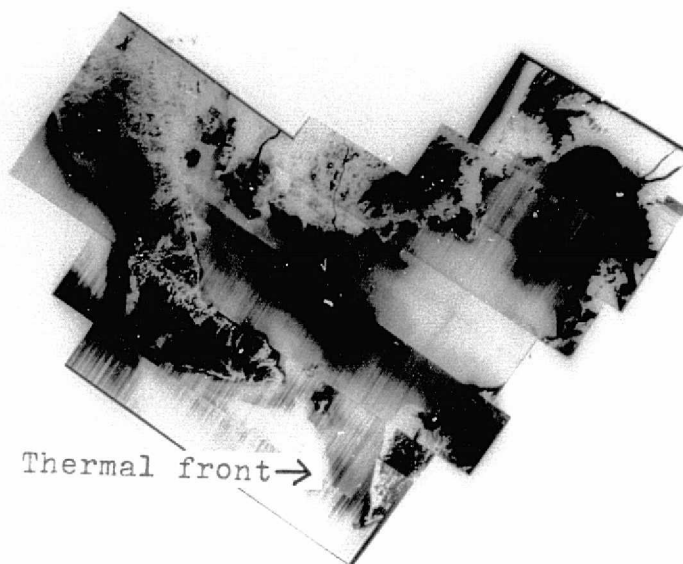


Figure 9 Mosaic of thermal imageries obtained
by aircraft around Mikawa Bay.
Oct. 24, 1974(10-42~11-45JST) Alt. 5330m

In Figure 1 and Figure 5, we could found out a front around the entrance of Mikawa Bay between Irago and Morozaki. This front is estimated as the boundary of oceanic water from the Pacific Ocean. Warm water mass from Pacific Ocean is dam up by cold water mass consisted in Mikawa Bay and cold water mass is estimated as influence of cold water from Yahagi River. As shown in Figure 8 and Figure 9, detected by air-born multi spectral scanner, a large scale thermal front is clarified around Irago Channel distinctly. The cold water from the Yahagi River is also well detected in Figure 9 as a thermal pattern.

The temperature difference at thermal front is estimated as 2°C in this case. Compared with Ise Bay, why the water in Mikawa Bay is so polluted is considered as its water exchange is disturbed by this thermal front through the year, especially in warm season. In previous day, we could not found out this thermal front from the data observed by vessel's routine survey or special survey around the Irago Channel. Although the reason why the oceanic water from the Pacific Ocean does not enter to Mikawa Bay was assumed by Unoki⁽²⁾ as that it was caused by topographical condition of sea bottom around the entrance of bay, the author would like to stress that cold water from the Yahagi River is more influent to disturb the proceeding of oceanic water.

3-3 Coastal change

The most effective wavelength for the detection of coast line is already clarified as MSS-7 channel in the author's previous report concern with LANDSAT-1. In Figure 10, we could pointed out the difference of coast line in northern part of Ise Bay near the mouth of Kiso River and Yokkaichi Port. In Figure 11, we also could pointed out the difference of coast line in eastern part of Mikawa Bay around Toyohashi Port.

In several areas indicated by black arrows large scale reclamation works has been continuing for the purpose of increasing the site for industry or agriculture and we could understood the state of reclamation works clearly. Around the Ise Bay and Mikawa Bay almost coastal change were caused by the reclamation works.

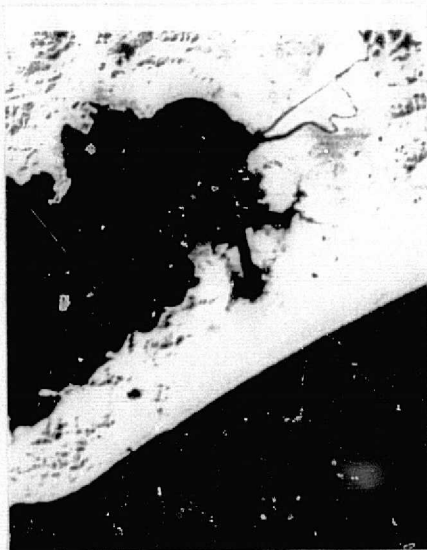


(a) Jan. 3, 1973



(b) Sept. 11, 1975

Figure 10 Coastal change in northern part of Ise Bay.



(a) Jan. 3, 1973



(b) Sept. 11, 1975

Figure 11 Coastal change in eastern part of Mikawa Bay.

3-4 Cold water mass

In early June of 1975, a cold water mass in large scale was suddenly appeared off the southern coast of Kyushu. This cold water mass is considered that it was consisted by up welling which is stronger than ordinary year. By the report of The Hydrographic Department of Maritime Safety Agency, the cold water mass shifted its position toward the northeast direction in very slow speed.

On the beginning of August the cold water mass was located at the position of 90 km from Shionomisaki in southeast direction and at this position it changed the proceeding direction to southeast.

The center position of cold water mass in early September was 180 km from Shionomisaki in southeast direction and the boundary of it was 220 km in major axis and 110 km in minor axis. The boundary of it was expanded as two times compared with one month ago. The water temperature at the depth of 100 m was 16°C, and at the depth of 200 m was 12°C in early September. These temperature were 5° or 6°C colder than at the same level in Kuroshio Current. So, warm Kuroshio Current was seriously influenced its moving direction.

As shown in Figure 12, Kuroshio Current has been meandered around the cold water mass and as the result of meandering a warm core was also consisted between two branch current of Kuroshio. In Figure 13, a eddy in large scale was detected in MSS-4 imagery and the scale of it exceed 30 km in major axis. This anti-clockwise eddy was estimated as the pattern of plankton which growth in the area of up-welling and it was formed by opposite flows of Kuroshio Current around the northwest corner of cold water mass.

3-5 River effluent

In Figure 13, river effluent from the Kumano River was identified clearly and it was recognized that the boundary of river effluence was influenced more than 50 km from the mouth of the river. After the heavy raining, the water quality of Kumano River was so polluted by suspended sediments that we could found out the distribution pattern beyond Shionomisaki. The most effective wavelength for the monitoring of river effluent was considered as MSS-4 channel, especially for the river where polluted by suspended sediments like as the Kumano River.

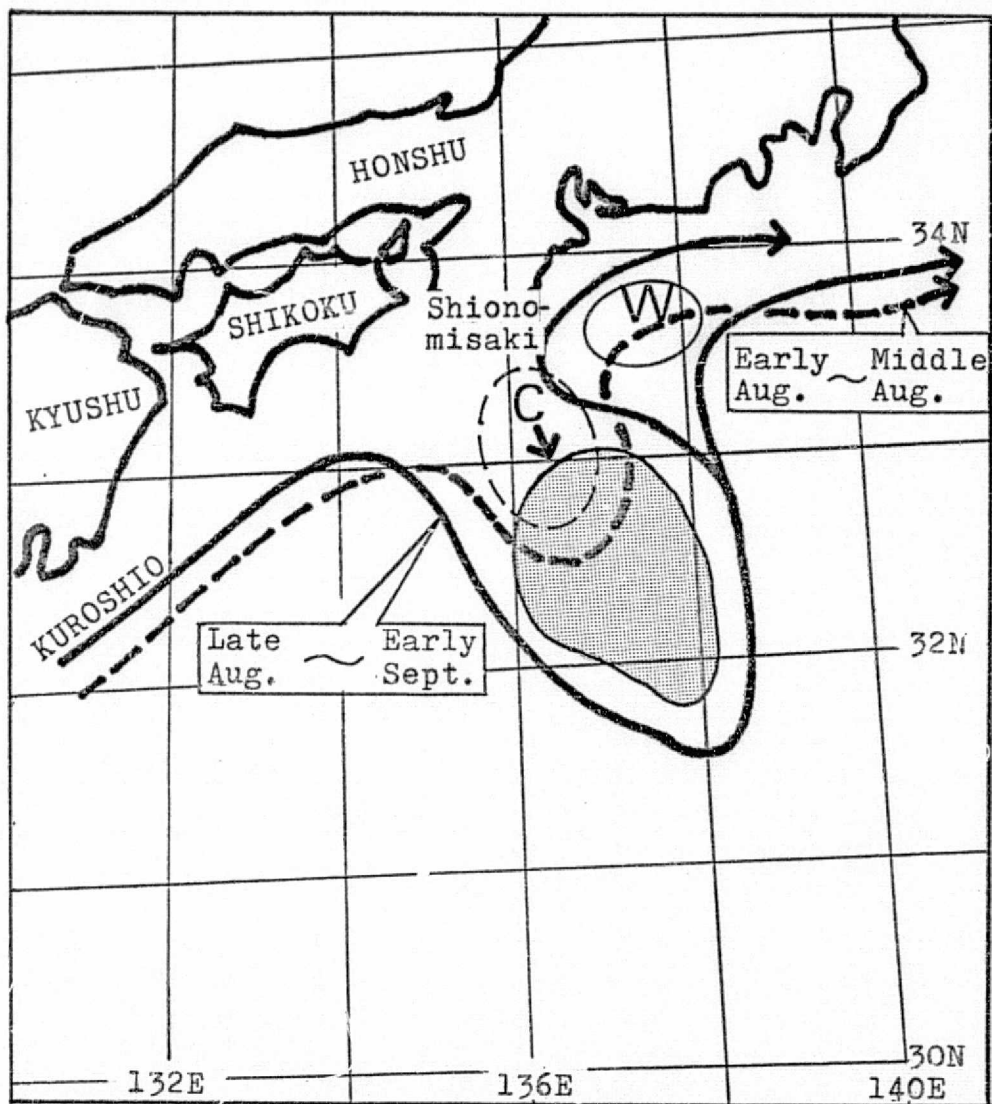


Figure 12 Location of cold water mass and abnormal flows of Kuroshio current from early August to early September of 1975.



Figure 13 Enlarged MSS-4 imagery which indicated the boundary of cold water mass. Sept. 11, 1975.

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In Figure 1, River effluent from the Tenryu River was indicated with black arrow and it was extended to eastwards along the coast line. Depend on the authors experience, the expanding pattern to eastwards is not normaly, because in another imageries obtained by LANDSAT-1, almost expanding patterns of river effluent from the Tenryu River were extended to westwards.

As shown in Figure 12, one of the branch current of Kuroshio Current was so approached to coast line abnormally in last September that, the river effluent from the Tenryu River was influenced in expanding direction toward to east.

3-6 Water bloom

Depend on the rapidly increasing of industrial and social effluence from the coastal area, the environment of Lake Suwa is seriously bad condition. As shown in Figure 14, we could found out the pattern estimated as the pollution in MSS-6 imagery.

So, the author tried special experiment around the Lake Suwa in last October using air-born remote sensing. As shown in Figure 15, Lake Suwa was polluted with the water bloom: *Microcystis aeruginosa* in warm season during the period the water temperature of the lake exceed 18°C and the reason why Lake Suwa was so polluted would be considered that the abnormal increasing of COD, $\text{NH}_4\text{-N}$ and $\text{PO}_4\text{-P}$. As the analysis of multi spectral scanner data obtained by aircraft were not compleated now, the author would like to report in next progressive report. Detected pattern in LANDSAT imagery was estimated that just the same pattern detected in aerial photograph caused by ship's discharge current.

4 Conclusion

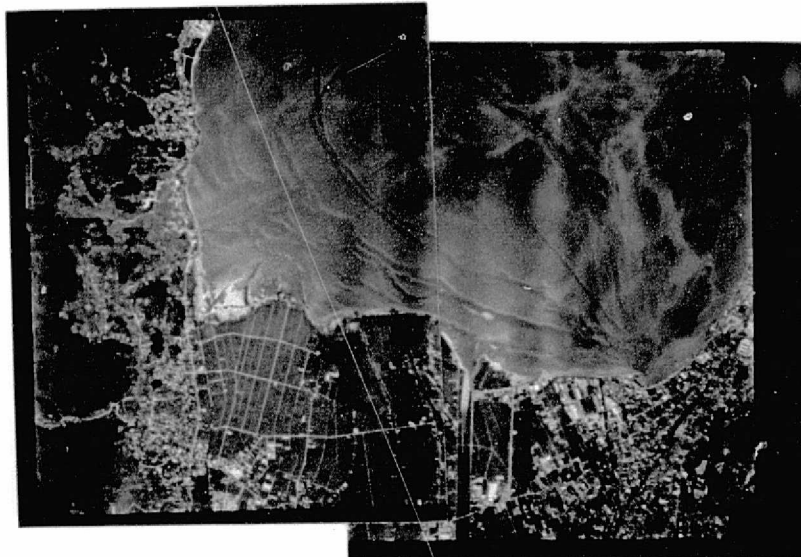
Although the data the author received were not so much in this period some of them were very useful data for the purpose of inquiry about marine environment. So, the author would like to receive more data acquired over central Japan.

References

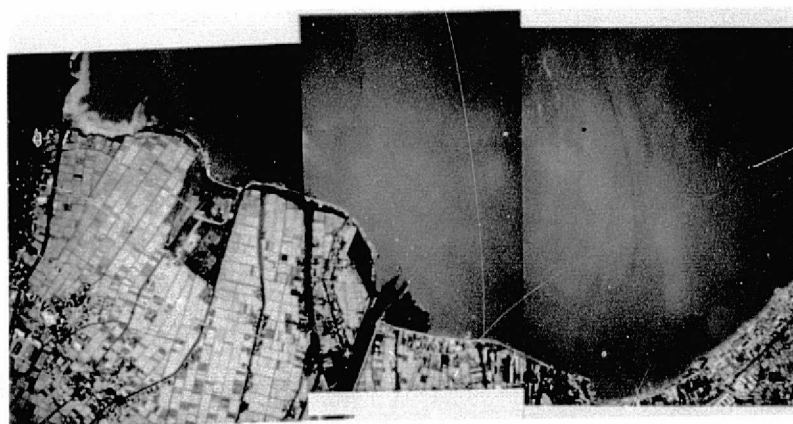
- (1) H. Ochiai: Application of SKYLAB Imagery to Marine Environment around Japan, Final report of SKYLAB study.
- (2) S. Unoki: Mean data of marine environment and water exchange in Ise Bay, Report on circulation system of polluted material in Ise Bay.



Figure 14 Enlarged MSS-6 imagery
detected water bloom in
Lake Suwa. Sept. 11, 1975



(a) Mid summer condition



(b) Early autumn condition

Figure 15 Aerial photograph mosaics of Lake Suwa.